of the holes was of a grayish color, but there were no remains of insects and no cast skins of the spider. Before opening the holes we sounded them with straws and tried to provoke the spiders to come out, but they took no notice of it. The drawing represents the ring of leaves and sticks, a section of the tube, and the spider at the bottom, all of the natural size.

## LICHENS UNDER THE MICROSCOPE.

BY H. WILLEY.

THE Lichens, though among the lowest, are also among the most abundant and widely distributed orders of plants. They are the earliest to cover the naked rocks with vegetation (though none, that we are aware, have been found in a fossil condition), and by their decay, to prepare a soil on which more highly organized plants can flourish. In the Arctic zone some species are so abundant as to furnish the reindeer with the food necessary for his subsistence, and are even used as fodder for cattle and swine, and are said to increase the quantity of milk. Recently they have been used for the manufacture of brandy—a very poor use to put them to—and were formerly much employed in dyeing. Hoffman, in his work on the uses of lichens, gives plates of over seventy-five tints obtained from them. But the recent scientific discoveries in this art, have greatly diminished their use for this purpose. Some were formerly used for medical purposes, frequently in accordance with the old doctrine of signatures. *Peltigera canina* was supposed to cure hydrophobia; *Sticta pulmonaria*, the consumption, etc. But they are now considered of little, if any importance, in medicine.

Arctic travellers have found in Umbilicaria, called *tripe de roche*, a poor and bitter substitute for food, when nothing

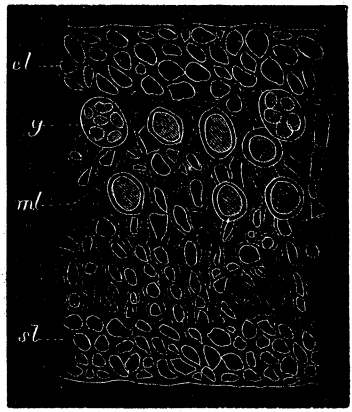
better could be obtained; and in Sweden bread has been made of the reindeer lichen in times of famine.

Lichens abound, also, in the temperate zone, especially in the mountains and the moist regions of the coast. Nearly three hundred species have been found in this vicinity (New Bedford). The number of known species, according to the most recent estimate (Krempelhueber, 1865), is about five thousand. They are to be met with everywhere. In swamps the trees are festooned with the pendulous *Usnea*. The foliaceous Parmelias, Stictas, etc., cover their trunks. The rocks and stones are everywhere covered with their spreading crusts. Some species grow on rocks covered with fresh or salt water. The brown, or scarlet fruited Cladonias, or "cup mosses," which the French call "herbe du feu" are spread over the earth. Some attain a diameter of two feet or more, while others are so small as hardly to be visible to the naked eye. Many of them are brilliantly colored, and exceedingly beautiful. They may be collected at any season of the year, are easily preserved, and their study, though not common among our botanists, owing, in a great degree, to the want of books on the subject in this country, and the necessity of using the microscope in order to become properly acquainted with them, is full of interest and instruction.

In the natural system of plants the lichens belong to the Cryptogamous, or flowerless series, which includes the ferns, mosses, algæ, and fungi. They rank below the mosses, having no distinct stem or foliage, but bearing their fruit on a foliaceous, shrubby, or crustaceous expansion, called a thallus, whence they are sometimes called Thallophytes. They have affinities on the one side with the algæ, and on the other with the fungi, and by some botanists have been included under one or the other of these orders. A recent writer, Schwendener, has propounded the theory that they are a compound plant, the thallus being a true alga, and the apothecium a fungus; but to this theory no true lichenist will be likely to assent.

The distinctive features of lichens consist in their having a thallus containing peculiar green cells, called gonidia, and in their spores being contained in asci, or spore-cases. In the latter particular the ascomycetous fungi resemble them, but these are always destitute of gonidia. A bluish reaction of the gelatinous substance of the apothecia is also characteristic of most lichens, though in some it is brown or red. In the fungi the reaction with iodine is yellow, except in a very few instances, where it is blue.

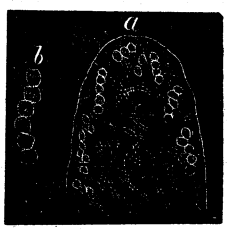
Fig. 139.




Section of thallus of *Theloschistes parietina*; *cl*, cortical layer; *g*, gonidia; *ml*, medullary layer; *sl*, inferior layer.

In order to investigate more closely the structure of the lichens, let us take any foliaceous lichen, *Theloschistes parietinus* (Fig. 139), for instance, the common orange-colored wall lichen, which occurs everywhere on stones and trunks; and having inserted a portion of the thallus in a slit made in a piece of soft cork, with a razor slice off as thin a cross-section as possible, and put it on a slide, with a drop of water, beneath a piece of thin glass, under the lens of our microscope. We shall see that it is composed entirely of cellular tissue, differing in this respect from those plants which have a vascular tissue. The upper surface, *cl*, we shall perceive to consist of a layer of cells composed of this tissue. Next beneath this is a stratum of round, greenish yellow bodies, *g*, called gonidia; then a stratum of elongated cells or filaments, *ml*, crossing each other in various directions, constituting the medullary layer; and lastly another row of cells forming the lower sur-

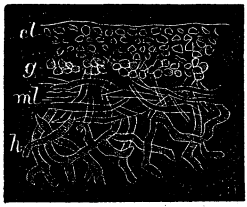
Fig. 140.




*Collema leptaleum*; *a*, section of thallus; *b*, moniliform gonidia.

face, *sl*, and from which proceed the slender fibres by which the plant is attached to the matrix on which it grows. These four layers make up the thallus of lichens. In some genera, as Collema (Fig. 140), the upper cellular layer is wanting, and the gonidia lie close to the surface; in others, as Peltigera, the lower is deficient, and bundles of long fibres proceed immediately from the medullary layer. These are very conspicuous and curious in *Parmelia colpodes* (Fig. 141). They constitute the hypothallus, which forms the substratum on which the other parts of the thallus are built up.

Fig 141.




*Parmelia colpodes*; *cl*, cortical layer; *g*, gonidia; *ml*, medullary layer; *h*, hypothallus.

In the fruticulose lichens, which bear some resemblance to the stem of a plant, the thallus is more or less rounded, and the gonidia are arranged around the medullary layer as an axis. In Usnea (Fig. 142) the thallus is solid, and the centre is composed of a mass of compact filaments lying parallel to the axis. In other genera it is hollow, or composed of loose filaments. In some genera, as Lichena, the medullary filaments, instead of running parallel to the axis, diverge from the centre to the circumference. In many crustaceous lichens the thallus consists of hardly more than a collection of gonidia, sometime buried beneath the bark, and of few filamentary elements. In these the hypothallus often forms a black border around the margin of the thallus.

Fig. 142.


*Usnea barbata*; *a*, longitudinal section of thallus; *b*, cross-section of the same.

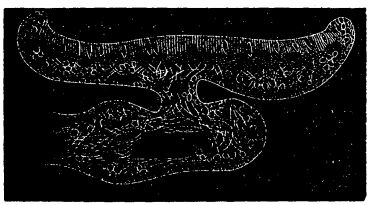
The gonidia constitute the peculiar characteristic of the lichen thallus, and are present in all true lichens, their presence being almost the only mark by which some can be

distinguished from fungi. There are some parasitic plants, consisting only of apothecia, which grow on the thallus of other lichens, called by Massalongo and Koerber, Pseudo-lichens, which are considered by some as lichens, by others as fungi. Most of them give the characteristic blue reaction with iodine. In examining a section of a young specimen of one of these, *Scutula Wallrothii* Tul. (*Biatora Heerii* Hepp), which grows on the thallus of *Peltigera canina*, I have seen a stratum of true gonidia underlying the apothecia, and extending around it. Some of these parasites are doubtless lichens, while others must be relegated to the ascomycetous fungi.

Fig. 143.

Granula gonima of *Sticta fuliginosa.*

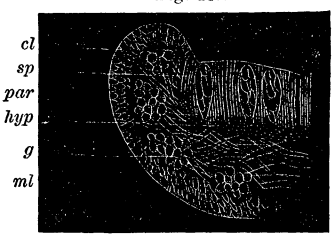
Fig. 144.



Section of apothecium of *Theloschistes parietina.*

The gonidia are either of a greenish yellow color, as mentioned above, as in Physcia, Parmelia, and the greater number of lichens; or of a bluish green, as in Collema, Peltigera, some Stictas, etc. These latter are called granula gonima, or collegonidia. In Collema they are strung together like a chaplet of beads, and are called moniliform (Fig. 140, *b*). In some genera they spring from the end of thalline filaments, in others they are grouped together, enveloped in a transparent gelatinous substance, and surrounded by a thin membrane (Fig. 143). In Synalissa both kinds of gonidia occur. They frequently burst into mealy excrescences, called soredia, on the surface of the thallus, and have the faculty of multiplying by self-division and of propagating the plant,

Fig. 145.




Portion of same more enlarged; *cl*, cortical layer; *sp*, spore-cases; *par*, paraphyses; *hyp*, hypothecium; *g*, gonidia; *ml*, medullary layer.

and in this way many lichens on which apothecia rarely or never occur, are multiplied. In some Verrucarias there are small gonidia, called hymenial gonidia, included in the hymenium.

The gelatinous substance which is found in the thallus is called lichenine. It is of a starchy nature. In many crustaceous lichens, oxalate of lime is present in considerable quantities, and may be easily recognized by its octahedric crystals. Phosphate of lime, salt, sugar, oil, with various peculiar acids, also occur, but not in great abundance.

Having thus viewed the principal features of the lichen thallus, let us now turn our attention to its organs of fructification. On looking at the lichen (Theloschistes) already selected, we shall see its surface covered with small round disks of nearly the same color as the thallus. These are the apothecia (Fig. 144), and contain the spores, the reproductive organs of the plant. Making a thin perpendicular section of one of these, and placing it under our lens, we shall see that it is surrounded by a margin containing gonidia like the thallus. The interior (Fig. 145) is composed of a mass of parallel filaments, called paraphyses, among which are the asci, or spore-cases. This interior portion is called the hymenium. That part which contains the paraphyses and asci is called the thalamium, and the portion below it, the hypothecium.

Those lichens whose fruit has an open disk, are called gymnocarpous. The margin of the disk is called the exciple. When formed from the thallus, and containing gonidia, it is called a thalline exciple; when otherwise, a proper exciple. The thalline exciple is usually pale, yellow, brown, red, or of the same color as the thallus, though it often blackens. The proper exciple is either black, as in Lecidea, or colored, as in Biatora. But in many lichens with a thalline exciple, it often assumes a biatorine form. The exciple is sometimes double, as in Gyalecta. The color of the disk varies greatly, being flesh-colored, yellow, red, brown, or

black. In some species, as *Nephroma arctica* and *Parmelia perforata*, the apothecium attains a large size. In Cladonia it is borne on the summit of a hollow stalk, called a podetium; in Calicium on a slender solid stem. In the Graphides, or "written" lichens, the apothecia are elongated and narrow, branched or stellate, and bear a rude resemblance to written characters.

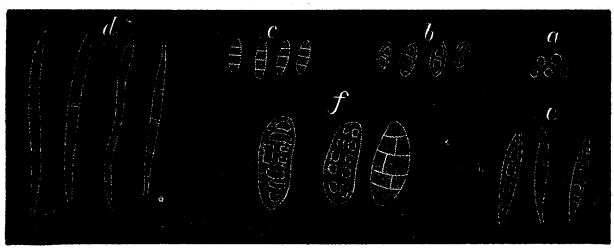
Fig. 146.

Spore-case of *Thelotrichistes parietina*, with spores.

In many genera, such as Verrucaria, the apothecia are closed, and these are called angiocarpous. These apothecia are usually black, conical, with a small opening at the summit. Their covering is sometimes called the perithecium. But there is no fixed line of demarcation between the gymnocarpous and the angiocarpous lichens.

The paraphyses are sometimes long and thread-like, and

Fig. 147.



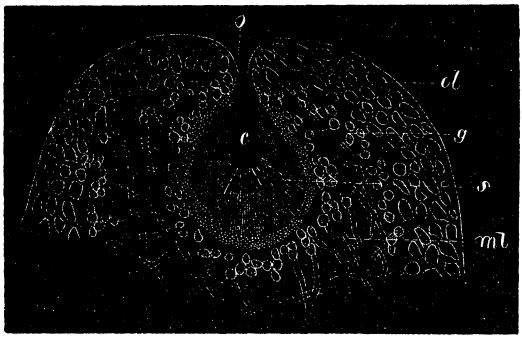

Spores. *a*, simple colored spore of *Calicium phæocephalum*.
*b*, diblastish " " *Ramalina calicaris*.
*c*, tetrablastish " " *Buellia vernicoma*.
*d*, acicular " " *Biatora rubella*.
*e*, fusiform " " *Collema flaccidum*.
*f*, muriform " " *Buellia petræa*.

easily separated, sometimes short and closely agglutinated, and, as in Arthonia, are sometimes entirely wanting. In this genus the exciple is also wanting. The paraphyses and spore-cases are generally colored blue, sometimes red or brown, by a solution of iodine.

The spore-cases, which lie among the paraphyses, are sacks usually of an oblong or club-shaped form, sometimes lanceo-

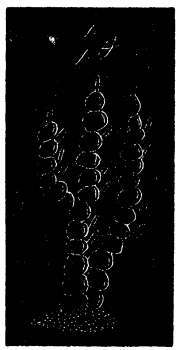
late or globose. In some genera, as Calicium, they disappear early, and the spores then appear to be free. But they are usually persistent, and a little pressure is required to separate the parts and bring out the spores. In the plant under examination there are eight of them in each spore-case. This is the usual number. But many species have one, two, four, sixteen, or more, or even several hundred spores in each spore-case. The spores differ greatly in size, form and color. In Theloschistes they are colorless, of an oval form (Fig. 146), with a small cavity at each end, sometimes connected by a small canal, and measure from twelve to sixteen thousandths of a millimetre in length. In other species they are of a brownish yellow, or a deep brown approaching black. The smallest spores are hardly two thousandths of a millimetre in diameter, while the largest are nearly two-tenths of a millimetre in length. In form they are globose, oval, elliptical, fusiform, needle-shaped, etc. (Fig. 147). Many spores are divided by one or more transverse partitions, and these again sometimes by perpendicular ones. The former are called *di-tetra-pleio-*, or poly-blastish; the latter muriform, and spores like those of Physica, polar-bilocular. Their great variety of form and color renders them most interesting objects under the microscope, and they are of

Fig. 148.




Section of Spermogonea of *Theloschistes parietina*. *cl*, cortical layer; *g*, gonidia; *o*, ostiolum; *c*, cavity; *s*, sterigmata; *ml*, medullary layer.

Fig. 149.



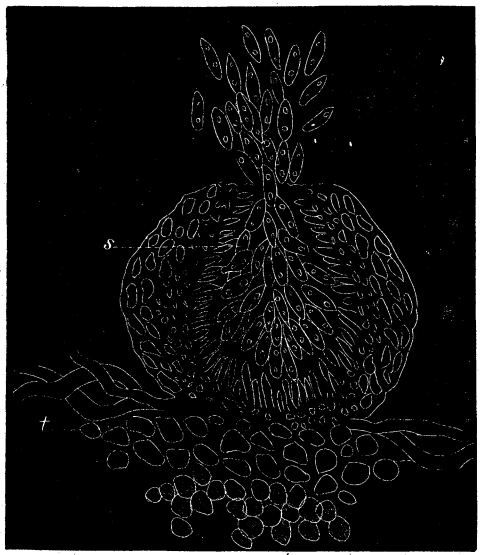
Sterigmata and spermatia of the same.

great importance in the determination of species, so that the study of lichens cannot now be successfully or thoroughly prosecuted without an acquaintance with them. Their general form and color being constant in each genus and species, they have, as Professor Tuckerman observes (Lichens of California), "added a new content to the conception of species." While their study opens fresh difficulties and perplexities to the student, it affords him a deeper insight into the inscrutable mysteries of nature, who, whatever we may strive to ascertain, ever holds some secrets in reserve which are beyond our grasp.

Fig. 150.

Spermatia.

Fig. 151.



Section of pycnide of *Biatora Heeri*. *s*, stylospores; *t*, thallus of *Peltigera canina*.

In its earliest stages the spore-case appears filled with small globular granules, in which lines of division appear, and the spores gradually assume their regular form and number. The spores are at first colorless and simple, and their internal divisions and changes of color may be seen in all gradations in the same hymenium. They frequently remain filled with a mass of oil globules. They are sometimes arranged in a linear

series in the spore-case, sometimes irregularly grouped, and sometimes spirally twisted around a central (ideal) axis. When ripe they are expelled from the spore-case by the pressure of the paraphyses, which when moistened, absorb water copiously. Many observations have been made as to the manner of the development of the thallus from the spore, but the matter is still involved in a good deal of obscurity.

Fig. 152.

Portion of pycnide of *Biatora Heerii* more highly magnified, showing the stylospores.

On the thallus of most lichens are to be seen a number of small black dots, either scattered irregularly over its surface, or along the margin. These are the spermogonea (Fig. 148), and they contain, in great numbers, the spermatia, which are extremely minute, cylindrical, or needle-shaped bodies, situated on the extremities of simple or branched filaments, called sterigmata (Figs. 149, 153). Their forms appear to be constant in each species, but are much less diverse than those of the spores, and they are always colorless. They have been supposed to be the male organ of reproduction, but nothing is certainly known of their functions. Nylander, who attaches much importance to the spermatia in his Synopsis, distinguishes five forms of them. 1st, the acicular slightly swollen at one end, as in Usnea; 2d, acicular slightly swollen near the extremity, as in Evernia; 3d, straight acicular or cylindrical, as in most Lecanoras; 4th, bowed acicular, or cylindrical, as in some Lecanoras; 5th, ellipsoid or oblong, as in Calicium, which last, he says, approach rather too near the short cylindrical spermatia. There are no spherical spermatia. But he is not fortunate in attempting

Fig. 153.


Spores (*a*), sterigmata and spermatia (*b*) of *Biatora Heerii*.

to apply these distinctions, and it seems difficult to render them of any great systematic value. Leighton, who has described and figured the spermatia of a large number of lichens, has failed in many instances to recognize the differences in form indicated by Nylander, especially in regard to the first two forms, and points out a great confusion in the application of Nylander's idea in his Prodromous and Synopsis in regard to the spermatia of Platysma (Cetraria). In figure 150 (*a*, spermatia of *Pyrenula lactea* Mass.; *b*. *Verrucaria epigæa* Pers.; *c*, *Synalissa phylliscina; d*, *S. phæococca* Tuck.; *e*, *Lecanora athrocarpa* Duby; *f*, *Parmelia colpodes* Tuck.; *g*, *Cetraria ciliaris* Ach.; *h*, *Placodium camptidium* Tuck.), we give a few additional illustrations of the different forms of spermatia. A slight but distinct crackle is almost invariably heard on crushing the spermogonia under the thin glass, which seems peculiar to these organs. Besides the spermogonia, there are also other small bodies, resembling them in external appearance, called pycnides (Fig. 151), but containing spore-like bodies called stylospores (Fig. 152), on the extremities of short filaments. They are often septate. Their office is unknown, and they are of comparatively infrequent occurrence.

## REVIEWS.

THE EARED SEALS.*—Up to the year 1866, comparatively little attention had been paid to the systematic relations *inter se* of the seals, and in that year, Dr. John Edward Gray, in the "Catalogue of the Seals and Whales in the British Museum," adopted essentially the same classifica-

*On the Eared Seals (*Otariadæ*), with detailed descriptions of the North Pacific species, by J. A. Allen. Together with an account of the habits of the northern fur seal (*Callorhinus ursinus*), by Charles Bryant. [1 pl. 108 pp., 3 pl. 3l. exp.] Bulletin of the Museum of Comparative Zoology [etc.]. Vol. II. No. 1.

The copy which we owe to the kindness of the author, is further illustrated by two photographic plates of *Zalophus Gillespii*.